IMMEDIATE BREAST RECONSTRUCTION–IMPACT ON RADIATION MANAGEMENT

Ravi A. Shankar, MD, J Rao Nibhanupudy, MS, Rajagopalan Sridhar, PhD, Cori Ashton, BS, RT, and Alfred L. Goldson, MD, FACR.

Breast reconstruction is an option for women undergoing modified radical mastectomy due to a diagnosis of breast cancer. In certain patients, breast reconstruction is performed by insertion of a temporary tissue expander prior to the placement of permanent breast implants. Some of these patients, following mastectomy, may require chest wall irradiation to prevent loco regional relapse. The compatibility of radiation and tissue expanders placed in the chest wall is of major concern to the radiation oncologist. Clinically undetectable changes can occur in the tissue expander during the course of radiation therapy. This can lead to radiation treatment set-up changes, variation in tissue expansion resulting in unwanted cosmesis, and deviation from the prescribed radiation dose leading to over and/or under dosing of tumor burden. At Howard University hospital, a CT scan was utilized to evaluate the status of the temporary tissue expander during radiation treatment to enable us to prevent radiation treatment related complications resulting from dosimetric discrepancies. CT images of the tissue expander were obtained through the course of treatment. To avoid a 'geographic miss' the amount of fluid injected into the tissue expander was kept constant following patient's satisfaction with the size of the breast mound. The CT scans allowed better visualization of the prosthesis and its relation to the surrounding tumor bed. This technique ensured that anatomical changes occurring during radiation treatment, if any, were minimized. Repeated dosimetry evaluations showed no changes to the prescribed dose distribution. A CT of the reconstructed breast provides an important quality control. Further studies with greater number of patients are required for confirming this impact on radiation treatment. (*J Natl Med Assoc.* 2003;95:286-295.)

Key words: breast cancer ◆ reconstruction ◆ tissue expander ◆ radiation treatment

INTRODUCTION

In women, breast cancer is the most common malignancy and the second most common cause of death in the United States[4]. About 1 in 7 women are likely to develop breast cancer[4]. Modified radical mastectomy is one of the standard treatment options for breast cancer[17,18,19]. Quality-of-life issues are attracting more attention following such curative procedures[24,31]. Following modified radical mastectomy, many women opt for immediate breast reconstruction[5,9,12,27]. Following this surgery, some women may have an inadequate area of skin, which can be a problem in many breast reconstructions[36]

In the 1980s, Rodovan[3] introduced the technique of tissue expansion using inflatable ex-

© 2003. Department of Radiation Oncology, Howard University Hospital, Washington DC 20060. Address correspondence to: Ravi A. Shankar, MD, Department of Radiation Oncology, Howard University Hospital, Washington DC 20060, Tel: (202) 865 1421, Fax: (202) 865 3690, email: ravishankar_2000@hotmail.com

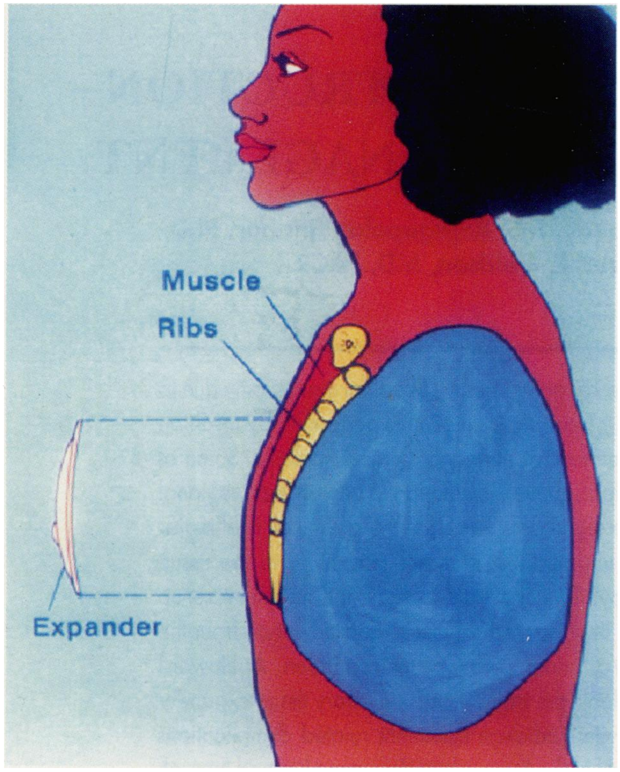

Figure 1. A temporary tissue expander that is inserted subcutaneously at the time of mastectomy

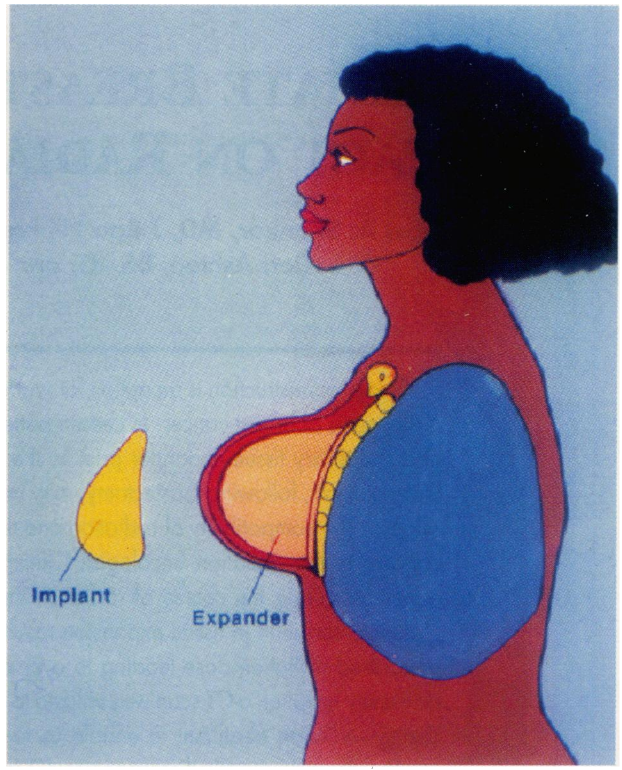

Figure 2. The temporary tissue expander is replaced with a permanent breast prosthesis following adequate expansion of skin, 4–6 months later.

panders that has rapidly become one of the methods of breast reconstruction[8,11]. This allows development of adequate area of skin so that an appropriate and acceptable permanent implant can be placed at a later date. The temporary tissue expander is inserted subcutaneously (fig 1) at the time of mastectomy. Three to 6 months later, the temporary tissue expander is replaced with a permanent breast prosthesis (fig 2). This method has the advantage due to its simplicity and the perfect texture and color match obtained after tissue expansion[27]

Radiation therapy is an integral part of the management of breast cancer[8]. The issue of irradiating the prosthetically augmented breast is being encountered with increasing frequency[16]. In such patients, radiotherapy is need for preventing loco-regional relapse[24]. Following mastectomy and reconstruction, indications for adjuvant radiotherapy include positive deep surgical margins, four or more involved axillary lymph nodes, extra capsular nodal extension, skin involvement, stages T3, T4 and N3 and recurrent breast carcinoma[25]. Radiation therapy is also necessary in carcinoma arising in cosmetically augmented breasts[30], carcinoma occurring after a mastectomy and reconstruction for severe fibrocystic disease, and inner quadrant or central tumors with metastatic axillary nodes.

Earlier, Jackson et al[1], studied the outcome in 10 Howard University Hospital patients who received post-mastectomy radiation following insertion of a temporary tissue expander. A two-year follow-up indicated good cosmesis in the majority (7 out of ten) of the patients. Of the remaining, one patient developed a leak from her prosthesis necessitating removal of

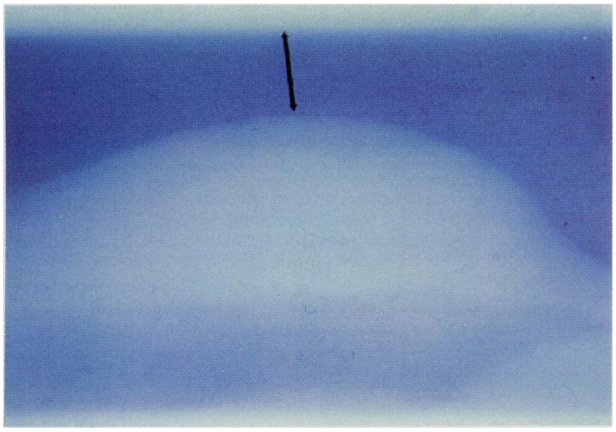

Figure 3. Normal simulation film revealing that the whole "breast mound" is completely and adequately in the planned radiation port.

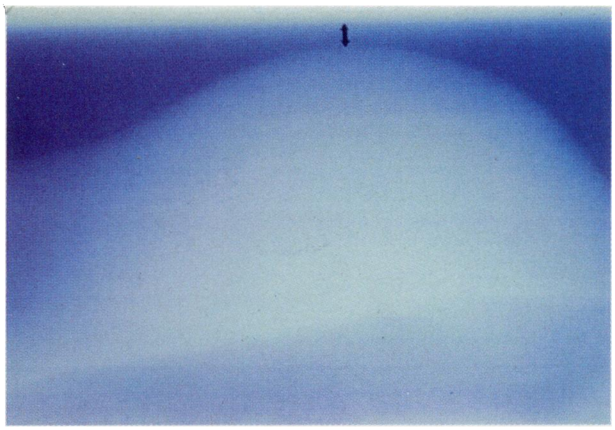

Figure 4. Mechanical stress and strain of the prosthesis during radiation can cause the prosthesis to expand anteriorly abnormally. This can lead to dosimetric discrepancy.

her prosthesis. In the other two patients, the damaged prosthetic device had to be removed resulting in poor wound healing, seroma formation and tissue necrosis. These defects were not noticed during the course of radiation treatment and during routine examination. Detection of damage occurring in the temporary tissue expander during the course of radiotherapy might have averted the failures.

Subtle geometrical changes occurring in the prosthesis such as leaks, shape-volume alterations, and changes occurring in tissues adjacent to the tissue expander can be imperceptible to the radiation oncologist during the course of treatment. Furthermore, the mechanical stress and strain of the prosthesis during radiation can cause it to expand abnormally and extend beyond the planned radiation treatment field (fig 4 and 5), leading to dosimetric discrepancy. Heightened concern about this problem prompted us to monitor the temporary tissue expander and its surroundings at different stages of radiation treatment.

The medical literature is replete with papers on the cosmetic outcome of breast reconstruction following irradiation[2,3,6,7,10,13,15,20]. Surprisingly few of these articles discuss ways to monitor the prosthesis during the course of radiation treatment, apart from clinical examination. Changes occurring to the prosthesis in relation to the surrounding structures can lead to significant changes in the planned dosimetry, which in turn can cause inaccuracies in radiation delivery in such patients[14]. Radiation oncologists should ensure the accuracy and precision of the delivery of radiation during treatment. To achieve this, it is important that the implanted prosthesis does not undergo any alterations during radiation therapy. We feel that addition of an imaging tool during the course of radiation treatment may help us to mitigate this problem. In this paper, we address this concern.

OBJECTIVE

During the course of radiation treatment, standard quality control measures are used to monitor the accuracy of delivery of radiation and adherence to the planned treatment protocol. In addition to the routine machine calibration checks, other measures include: (i) clinical examination, (ii) verification of patient position on the treatment couch, and (iii) port film (fig 3) checks of the treatment field[41,42,43].

In spite of undertaking the above-mentioned quality control measures, in the case of radiation delivery to the breast with a tissue ex-

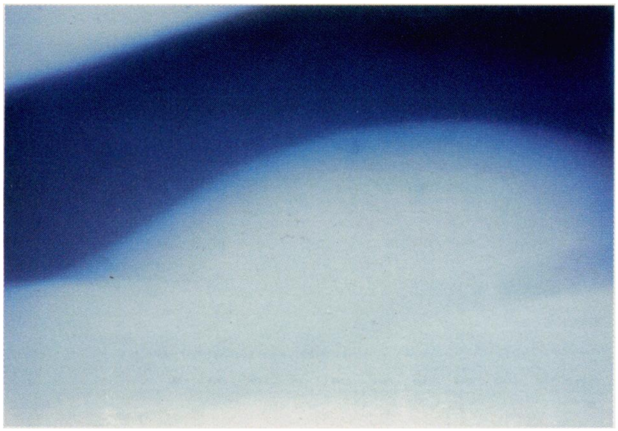

Figure 5. Mechanical stress and strain of the prosthesis during radiation can cause the prosthesis to expand superiorly abnormally and extend beyond the planned radiation treatment field.

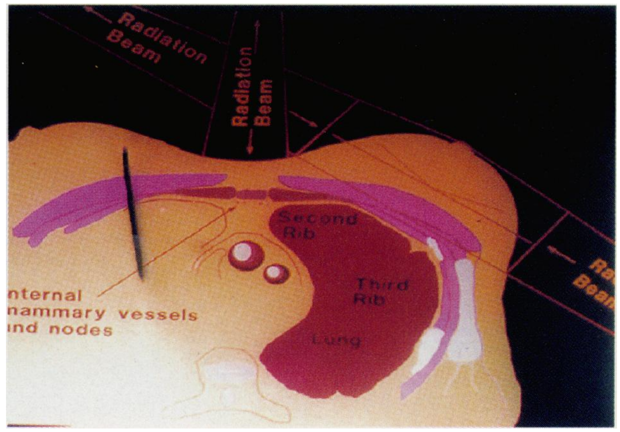

Figure 6. The external beam radiation treatment to the whole breast mound consists of a standard protocol of 5040 cGy in 180 cGy fractions, via 6 MV photon tangents, given over a period of 6 weeks

pander in place, subtle changes in the prosthesis can escape detection. This can lead to serious dosimetric inaccuracies causing over and/or under dosing of the treatment volume. This will result in failure of loco-regional control apart from poor cosmesis[40].

In the radiation treatment of an augmented breast with a temporary tissue expander, failure of radiation therapy to prevent loco-regional relapse can be attributed to deviations from the prescribed dose distribution and planned treatment volume. This can be due to: (i) fluctuations in shape and volume of tissue expander during the course of therapy, (ii) possible damage to the tissue expander, (iii) changes occurring to the surrounding structures such as ribs and chest wall (iv) presence of seroma, infection, necrosis and capsular contracture (v) spontaneous changes (expansion or deflation) occurring in the prosthesis[3]. There is a need for establishing quality control parameters in patients with temporary tissue expanders who are candidates for radiation treatment.

PATIENT AND METHODS

A breast cancer patient who had undergone placement of a temporary tissue expander immediately following modified radical mastectomy, was evaluated for receiving external beam radiation therapy to the breast mound. Due to the presence of a 6.3 cm tumor as well as involvement of 8 axillary lymph nodes, this patient was recommended to receive post-operative external beam radiation treatment to the chest wall. The patient gave informed consent to receive definitive radiation treatment.

In the past[1] at our institution, we had encountered adverse affects in such patients having a temporary tissue expander in place and receiving radiation treatment. Three out of 10 patients, had to have their prosthesis removed due to complications. This had lead to unacceptable cosmetic results. One patient developed a leak in the prosthesis. In two other patients, undiagnosed damage to the prosthesis resulted in poor wound healing and seroma formation leading to tissue necrosis. Taking our previous experience into consideration, we obtained a series of radiologic images (CT scans) prior to, during and at completion of radiation treatment (fig 7 & 8). This enabled us to detect changes early and prevent any untoward changes. The CT images were used to monitor and record any possible changes in the temporary tissue expander itself and the surrounding structures adjoining the prosthesis.

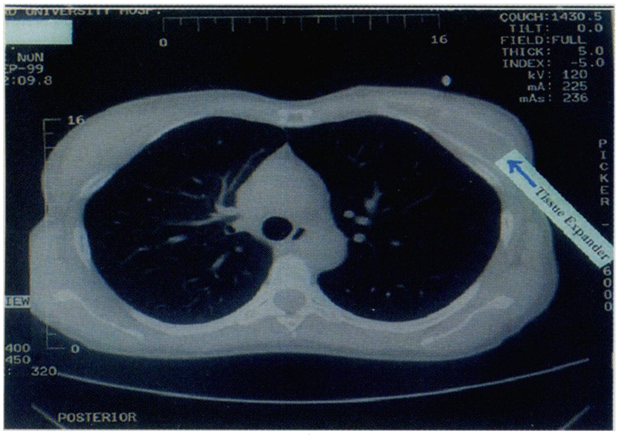

Figure 7. CT scans obtained prior to initiation of radiation documenting the prosthesis and its relation to adjacent structures.

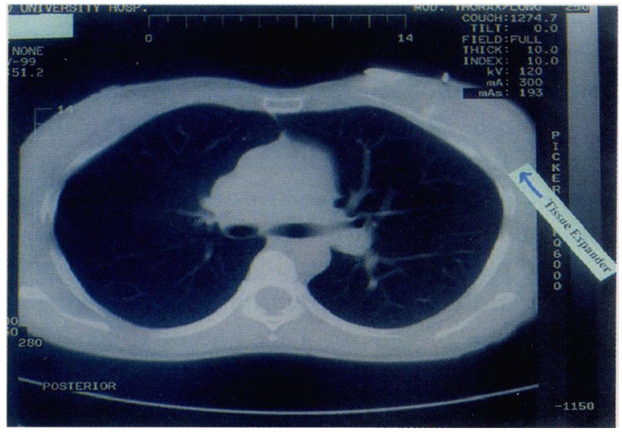

Figure 8. CT scans obtained at completion of radiation treatment. No abnormalities were noted in the prosthesis or in the structures adjacent to it.

The patient, plastic surgeon and other members of the medical team were kept informed of our plan. The normal expansion of the prosthesis was achieved by injection of saline through a valve connected to the prosthesis. The expander was initially filled with 50 to 100 ml of normal saline through the connecting tube. Subsequent normal saline injections of approximately 50 ml were undertaken in 3 to 5-day intervals until the size and appearance of the breast mound was acceptable to the patient and the surgeon. Usually the expanded breast is about 150 to 200 ml larger than the projected size of the permanent prosthesis. To make sure that there were no volume changes in the prosthesis during radiation treatment, the amount of fluid in the prosthesis was kept constant (750 ml) following patient's satisfaction with the size and appearance of the breast mound. This was done prior to initiation of radiation therapy and acquisition of the pre-treatment radiologic images. Moreover, the relative position of the prosthesis with respect to the surrounding structures was recorded. Comparisons were also made among the CT scans obtained during the course of radiation therapy to judge the geographical changes.

The external beam radiation treatment to the whole breast mound (fig 6) consisted of a standard protocol of 5040 cGy in 180 cGy fractions, via 6 MV photon tangents, given over a period of 6 weeks[1,24].

We also undertook additional studies on the effects of improper expansion of a breast prosthesis using the "Alderson-Rando" body-shaped phantom, made of tissue equivalent material. We simulated various hypothetical geometries of prosthetic deformations. Radiologic simulations were obtained of these hypothetical conditions of improper expansions of the prosthesis. Dosimetry calculations were performed for each hypothetical simulation. Computerized calculations of the dosimetric variations were obtained. The photon dose distributions of these hypothetical conditions were compared to the dose distribution obtained on an undeformed prosthesis.

RESULTS

The patient in our study was closely monitored using CT scans, which delineated the breast prosthesis and its adjacent structures clearly. No untoward changes were noted throughout the entire course of radiation treatment. In particular no contour and shape changes such as dimpling, tenting, crimping were noticed. The prosthetic device appeared intact with no evidence of fluid leakage, seroma formation or tissue necrosis. No changes were noted to the structures in close relation prosthesis, such as ribs, muscles and chest wall.

Multiple dosimetric calculations performed during treatment, revealed acceptable changes (+/- 2%) in the dose distribution of the breast mound throughout the radiation course.

The patient completed her radiation course on schedule, with no treatment breaks. During the course of radiation treatment the patient did not experience any unacceptable side effects. Clinical examination during treatment was normal with no signs of seroma, infection or tissue necrosis. She did not experience any untoward pain requiring medications. Weekly port films revealed no abnormalities confirming that prosthesis was well within the planned radiation field. At completion the routine post radiation instructions were given. The placement of a permanent prosthesis was scheduled at 4 months post radiation treatment. During this observation period, no alterations were done to the prosthesis, such as increasing or decreasing the volume of fluid. She was followed up by us and by her surgeon. Following completion of treatment, we did a 15-day, 3-month and 6-month follow-up on the patient. No unacceptable loco-regional effects were seen. Also cosmetic changes, like skin discoloration, were comparable to those encountered in patients receiving radiation therapy to an intact breast. The surgeon explained that he did not experience any difficulty in the dissection of the prosthetic bed or in the insertion of the permanent breast prosthesis. No abnormal wound healing reactions were noted post-operatively. The patient was satisfied with her cosmetic appearance.

However, in the dosimetric calculations performed on hypothetical situations with exaggerated prosthesis deformations, gross discrepancies were evident. In one case, an additional amount of fluid (50 ml) was injected. This caused a 1cm extension of the prosthesis outside the superior border of the planned radiation treatment field. In this instance computer dosimetry calculations revealed greater than 10% variation from the original treatment dose. Similarly deliberate dimpling of the prosthesis resulted in dosimetric discrepancy greater than 10% above the accepted norm. Also deflation of the prosthesis, caused by removal of fluid, resulted in unsuitable dosimetric plans. In radiation therapy, greater than 10% variation of dosimetric plan is unacceptable[39,40]. Such changes in the size and shape of the tissue expander cause either over and/or under dosing and decreases the probability of tumor control. This can result in a high incidence of loco-regional failure of the cancer treatment, apart from causing psychological stress to the patient, pain, morbidity due to multiple surgical interventions and poor cosmetic result.

Even though we did not simulate any leakages in the prosthesis, review of literature reveals that leakage leads to loco regional failure as well as improper cosmesis. These are explained further in the discussion part of this paper.

DISCUSSION

Certain breast cancer patients are candidates for modified radical mastectomy. A few of these patients require chest wall radiation. The increasing awareness of self-image and psychological issues make breast reconstruction an option for some of these patients. The reconstruction can be performed after radiation to the chest wall or at the time of radical mastectomy. Surgical augmentation following radiation to the chest wall is fraught with complications and adverse cosmetic effects exist[6,10,22,29,38]. Many women opt for immediate breast reconstruction using autologous tissue (flaps) or by the insertion of a temporary prosthesis. Presence of the breast mound soon after radical breast surgery is also known to add to the psychological benefits[32]

In a few individuals, following radical mastectomy, the lack of adequate skin covering over the chest wall makes placement of breast prosthesis difficult. This can be overcome by the use of temporary tissue expanders to create an adequate skin volume. The permanent prosthesis can then be accommodated at a later stage.

In such patients, while awaiting adequate skin expansion and with a temporary tissue expander in place, radiotherapy may be required to prevent loco-regional relapse[24]. Criteria for patients requiring radiation following mastectomy include presence of positive deep surgical margins, four or more involved axillary lymph nodes, extra capsular nodal extension, skin involvement, stages T3, T4 and N3 and recurrent breast carcinoma[25].

The compatibility of radiation treatment and breast reconstruction using temporary tissue expanders is of serious concern[8]. Even though immediate reconstruction is practiced there is concern that temporary tissue expander may perform suboptimally following exposure to radiation. The complications of radiation include improper filling of the expander, spontaneous expander deflation problems[21], rib denting[23,26], deformation of the thoracic cage[33], expansion without projection, thinning of tissues over the prosthesis, and necrosis of adjacent tissues. The complications related to radiotherapy are radiation induced endovasculitis and destruction of the network of elastin fibers.

Sometimes the prosthetic devices can develop microscopic leaks causing accumulation of fluid under the tissues. This can lead to inflammation, infection and edema due to such leakages[27]. Such accumulations may not be detectable during routine physical examination, unless imaging studies are performed. The collection of fluid under tissue planes can also act as boluses and cause hot and cold spots in the radiation field. These distortions in dose distribution can lead to tissue necrosis and failure of treatment. Thus keeping the amount of fluid in the prosthesis constant as well as monitoring the treatment volume by suitable imaging techniques are critical aspects of radiation treatment

Timing of radiation therapy[37,38] is crucial for avoiding loco regional relapse. This is optimally done within 12-16 weeks of surgery. It is crucial that the radiation oncologist works along with the surgeon and educates the team about the role they play in such a setting. As most patients have their tissue expander prosthesis inflated by the surgeons, it is important to understand that slow and regular filling of the prosthesis by injection of saline is favored over a rapid and irregular filling technique[28].

Current literature is full of references pertaining to cosmetic outcomes following breast reconstruction[2,6,7,10,13,20]. As part of treatment planning and quality assurance physicists have compared dosimetry data for photon and electron beam radiation. In patients with breast reconstruction, the dose volume histograms (DVH) and differential DVH (dDVH) analysis have been performed in order to identify regions that are under dosed or over dosed (cold and hot spots). Drastic changes in DVH can result due to leakage of fluid form the expander or due to deformation of the prosthesis. Such deformation and leakage of fluid should be discernable from MRI or radiologic imaging. To date DVH analysis carried out have not been fruitful in detecting suboptimal performance of the expander[35]. Also such analysis has the disadvantage of not alerting us to very early changes before they become a major problem.

Current literature however, provides little clinical information on our ability to closely monitor the prosthesis during the course of radiation treatment. The purpose of our study was to add an imaging tool to verify any ongoing changes to the expander during the course of radiation

Physicists and other researchers have conducted studies on phantoms with breast implants. Phantom dosimetry data demonstrated no hot or cold spots due to the prosthesis[24]. These studies demonstrated that the prosthesis itself did not affect photon beam distribution. Other studies, wherein a permanent prosthesis is placed immediately following radical breast surgery did not lead to satisfactory results. This was attributed to radiation-induced effects on certain permanent prosthesis[34] depending on its composition. For example a silicon breast prosthesis or tissue equivalent gels may undergo substantial changes like discoloration and loss of tensile strength and elasticity. While the prosthesis themselves do not compromise dose distribution to the tumor bed, the durability of the prosthesis can be affected by radiation. There is concern that such adverse effects can make any future breast implants impractical. The use of a temporary tissue expander filled with saline negates these effects and may be a better option for the cosmetically concerned women.

Carrying out a second simulation during the course of radiation[35] may minimize the risk of adverse effects due to temporary breast prosthesis. While this may not be an issue for the radiation oncologist, it does inconvenience the patient and the therapy staff.

Additionally certain patients are not candidates for this form of treatment. They are patients known to have poor healing due to diabetics, connective tissue disorders, and vasculopathies. Also patients on chemotherapy[24] may not be ideal candidates. It may be relatively contraindicated in some older women[24].

By the addition of an imaging technique, we can observe the changes occurring in the prosthesis. This is a non-invasive technique with very little inconvenience to the team as well as no adverse effects.

CONCLUSION

Use of radiation in a patient with a prosthetically constructed breast needs careful consideration. Stringent quality control measures are needed for preventing loco-regional failure while preserving good cosmesis. Patients selected to undergo this procedure must be free of co-morbid factors that can lead to complications. Discussion of specific issues relating to the prosthesis and education of the surgeon will benefit the patient by promoting wound healing, preventing infection in the surgical bed due to good handling of tissues, well placed prosthesis and proper filling of the prosthesis. One must never forget that tumor control is also a primary objective in the management these patients.

Studies carried out on such patients have lead us to believe that type of radiation (photon vs. electron), dosimetry and DVH analysis, types of expanders themselves do not make a difference in the result, if there is no damage to the prosthesis. However, those patients with unacceptable cosmetic effects experienced changes to the prothesis that were not detected during the course of radiation.

Adverse effects can be mitigated by techniques that allow us to closely monitor the tissue expander during radiation. It is important to maintain a constant volume of fluid in the tissue expander throughout the treatment period. To optimize therapy frequent clinical examinations and treatment couch position checks should be done. Apart from the standard quality control measures, obtaining CT and /or MRI images of the tissue expander during the course of radiation serves as an important quality control parameter. Such images provide us with detailed information of the geometrical changes and alterations in the tissue expander, which in turn can predict dose distribution changes. Additional studies involving a greater number of patients are required for confirming the importance of imaging studies in the radiation management of patients with tissue expanders.

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